

# TESIS - THE TNG EROS SPECTROSCOPIC IDENTIFICATION SURVEY

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## 1. The TESIS project

The main scientific aims of the TESIS project are:

- i)* to measure the comoving density of massive ( $M_{star} > 10^{11} M_{\odot}$ ) elliptical galaxies at  $z > 1$ ;
- ii)* to study the properties of X-ray emitting Extremely Red Objects (EROs);
- iii)* to measure the star formation rate (SFR) of dusty EROs probing their connection with ULIRGs.

To this end we have started a near-IR very low resolution ( $\lambda/\Delta\lambda \simeq 50$ ) spectroscopic survey of a complete sample of 30 bright ( $K < 18.5$ ) EROs (Saracco et al. 2003, A&A 398, 127). The sample has been selected from the Munich Near-IR Cluster Survey (MUNICS, Drory et al. 2001, MNRAS 325, 550) over two fields ( $\sim 360 \text{ arcmin}^2$ ) covered by B, V, R, I, J and K-band observations. The red optical-to-near-IR colors ( $R-K \geq 5.3$ ) allow to select  $z > 1$  evolved stellar systems; the bright K magnitudes assure the selection of massive galaxies and the near-IR spectra allow the detection of the  $4000\text{\AA}$  break at  $z > 1$ . The survey is carried out at the 3.6m Italian Telescopio Nazionale Galileo (TNG) and employs the prism disperser AMICI. It is designed to cover the full spectral range (8000-25000 Å) in a single shot thus resulting extremely efficient in detecting continuum breaks and in describing spectral shapes. Up to now, 40% of the sample have been spectroscopically observed.

In parallel with the near-IR spectroscopic follow-up we obtained 150 ks of XMM-Newton observations for the two selected fields (75 ks each) to study the nature of the X-ray emitting EROs. The first set of XMM observations has been carried out in February 2003 while the second set is expected in fall 2004.

## 2. The density of $\mathcal{M}_{star} > 10^{11} M_{\odot}$ ellipticals at $z > 1$

We classified 10 out of the 13 EROs observed so far: 7 early-type galaxies and 3 starbursts. The properties of the 7 early-type galaxies are summarized in Tab. 1. Assuming  $\mathcal{M}/L_K = 0.5$  [ $M/L$ ] $_{\odot}$ , all of the 7 galaxies have already formed and assembled a stellar mass well in excess to  $10^{11} M_{\odot}$ . Thus they would populate the very bright end ( $L_{z=0} > 2L^*$ ) of the local luminosity function of galaxies (we considered  $M_K^* = -24.2$  from Cole et al. 2001,  $H_0 = 70$  Km  $s^{-1}$   $Mpc^{-1}$ ,  $\Omega_m = 0.3$  and  $\Omega_{\lambda} = 0.7$ ). These 7 ellipticals account for a comoving density of about  $2.6 \times 10^{-5} Mpc^{-3}$ . The number density of local  $L > 2L^*$  is  $7 \times 10^{-5} Mpc^{-3}$  (we used  $\phi_{E/S0}^* = 1.5 \times 10^{-3} Mpc^{-3}$ , from Marzke et al. 1998). Thus, they account for almost 40% of the local population of massive elliptical galaxies (Longhetti et al. 2003, in prep.). Since only 40% of the sample of EROs has been observed we expect that this density doubles at least. Hence, it is reasonable to expect that the density of  $\mathcal{M}_{star} > 10^{11} M_{\odot}$  ellipticals at  $z > 1$  is consistent with the local one.

Table 1. Photometric and physical properties of the 7 early-type galaxies.

EROs-ID	R-K'	K'	$z$	$M_K$	$\mathcal{M}_{star}$	$L_K^{z=0}$
	mag	mag		mag	$10^{11} M_{\odot}$	$L_K^*$
S2F1_142	6.0	17.8	1.40	-26.2	3.5	$> 2.5$
S2F1_357	6.0	17.8	1.30	-26.0	3.0	$> 2.0$
S2F1_389	$> 6.0$	18.2	1.35	-25.7	2.0	$> 2.0$
S2F1_527	5.9	18.3	1.40	-25.7	2.0	$> 2.0$
S2F5_109	5.3	16.7	1.20	-26.9	6.5	$> 4.8$
S7F5_45	5.8	17.6	1.45	-26.4	4.3	$> 3.0$
S7F5_254	$> 6.0$	17.8	1.22	-25.8	2.5	$> 2.0$

## 3. Are type 2 QSOs hidden in X-ray emitting EROs ?

The preliminary analysis of the 75 ks XMM observation centered on one of the two selected fields shows that 5 EROs have a secure X-ray counterpart down to a 2-10 keV flux limit of  $\sim 10^{15}$  erg  $cm^{-2} s^{-1}$ . None of them has been yet observed spectroscopically. Their X-ray-to-optical flux ratios and their 2-10 keV luminosities suggest the presence of an AGN in all of them. For three out of the 5 EROs it has been possible to perform a complete X-ray spectral analysis. The data are well fitted by a single power-law ( $\Gamma \geq 1.5$ ) which provides column densities  $N_H \geq 2 \times 10^{22} cm^{-2}$  and intrinsic luminosities  $L_{(2-10keV)} \geq 1.2 \times 10^{44}$  cgs. These results indicate the presence of high luminosity, obscured AGNs, i.e. QSO2 candidates (Severgnini et al. 2003, in prep.).